Physics 226: Problem Set #8
Due in Class on Thursday Nov 10, 2015

A helpful reference for this problem set is Goldhaber and Cahn (G&C) Chapter 7. A pointer to a computer accessible version of the chapter is available on our web page.

1. (G&C problem 7.3) Starting from the expression on the top of page 5 of Goldhaber and Cahn Chapter 7, verify the expression for the eigenstates of the neutral K system in matter:

$$\begin{aligned} |K_1^{0\prime}\rangle &= |K_1^0\rangle + r|K_2^0\rangle, \\ |K_2^{0\prime}\rangle &= |K_2^0\rangle - r|K_1^0\rangle, \\ r &= -\frac{\pi N \beta\gamma}{k} \cdot \frac{f_0 - \overline{f}_0}{m_1 - m_2 - \frac{i}{2}\Gamma_1}. \end{aligned}$$

   Estimate the size of the regeneration parameter in beryllium for a momentum of 1100 MeV, the conditions of the original CP violation experiment. Estimate f_0 and $\overline{f}_0$ (the forward K^0 and $\overline{K}^0$ scattering amplitudes) using the optical theorem and data for the K^+p and K^-p total cross sections.

2. (G&C problem 7.4) A beam of K^0 is created at $t = 0$. Assuming CP conservation, what is the intensity of $\overline{K}^0$ in the beam as a function of the proper time? Plot the results for $|\Delta m|\tau_1 = 0, 1, 2, \infty$. See Camerini *et al.*, *Phys. Rev.* **128**, 362 (1962).

3. (G&C problem 7.5) Consider a neutral kaon beam that is purely K^0 at $t = 0$. Show that the rate of decay into $\pi^+\pi^-$ as a function of the proper time, τ, is proportional to

$$e^{-\Gamma_S\tau} + 2|\eta_{+-}|e^{-(\Gamma_S+\Gamma_L)/\tau/2}\cos[\phi_{+-} - (m_L - m_S)\tau] + e^{-\Gamma_L\tau}|\eta_{+-}|^2.$$

4. Derive the expression on page 10 of Goldhaber and Cahn Chapter 7:

$$\delta_\ell = 2\mathrm{Re}\ \epsilon$$